State & Private Forestry
FOREST HEALTH PROTECTION
Northern California Shared Service Area

Date: December 21, 2023

Topic: Forest insects and diseases affecting trees in the Trinity Unit Campground Forest Health Project area, Shasta-Trinity National Forest (FHP Report NC24-001).

Key Points:

- ***The cool, wet, and snowy year brought major drought relief after three consecutive dry years. Groundwater infiltration and reduction of tree mortality can require more than one good year of precipitation.***
- ***Douglas-fir does not generally tolerate hot-drought conditions well. Current Douglas-fir mortality is primarily caused by flatheaded fir borer as a response to drought, but other agents may also be involved.***
- ***Deteriorating forest conditions at the recreation sites are fueled by high tree densities, drought, and human-caused damage to stems and roots which have led to insect and diseases causing increased tree mortality.***

Background: The Trinity Unit Campground Forest Health Project, consists of approximately 1,466 acres including 17 recreation sites within the Trinity Unit of the Whiskeytown-Shasta-Trinity National Recreation Area, forested patches between sites, and the area directly north of Trinity Center Airport including a portion of the Trinity Lake KOA.

Recent aerial survey and stand exam data show that the project area is experiencing declining forest health and at risk for substantially increased tree mortality. Changes in wildfire suppression and forestry practices over the past 100 years has resulted in a species composition shifts and tree densities much higher than they were historically or are sustainable. Current densities in the project area have reached levels that exceed site capability leading to tree stress. Drought and increased temperature are further stressing trees, leading to vulnerability to insects and disease and tree mortality.

For northern California, the cool, wet, and snowy 2022-2023 water year brought major drought relief after three consecutive dry years. Observed water year runoff was above normal throughout the summer and most major reservoirs were filled by the end of spring. Trinity Lake is a relatively large reservoir compared to the watershed that supplies it with much of the water falling as snow in the surrounding mountains. For this reason, Trinity is slow to fill relative to many other California reservoirs. As of Aug. 4, 2023, the Trinity Lake water levels were at 90 percent of their normal measurements. They are recorded at 1,400,097 acre-ft compared to the average of about 1,571,002.21 acre-ft. (SnoFlo https://snoflo.org/hydrology/watershed-h18010211-trinity)

Wet years are not unprecedented in the context of the current multidecadal drought. However long-term drought recovery is complex, and it is important to note that groundwater infiltration and recharge of aquifers, which is impacted by the characteristics of snowmelt, can take longer to respond and require more than one good year of precipitation. California’s climate can swing from wet years to dry years and back again with climate change increasing this variability.

Putting this information into context of forest health and the continued tree mortality trends in Northern California can be difficult. There are many areas in Shasta, Trinity, and Siskiyou Counties where Douglas-fir continues to die from attacks by the flatheaded fir borer (*Phaenops drummondi*) and mortality of ponderosa pine increased over the last year due to western pine beetle (*Dendroctonus brevicomis*). Other tree species experiencing increased mortality over the past year include true firs and incense cedar, each for a variety of reasons but thought to be driven by hot and droughty conditions. Tree mortality is extremely high in Trinity and Shasta Counties and may have an impact on summer recreation.

Observations and Discussion: On our visits to the project area we have observed western pine beetle (WPB) causing mortality in ponderosa pine and flatheaded fir borer (FFB) causing mortality in Douglas-fir. The 2022 Aerial Detection Survey (ADS) results for the state reported that nearly all Douglas-fir mortality was caused by flatheaded fir borer with an estimated 3 million dead trees across 190,000 acres, compared to ~170,000 dead trees across 18,000 acres in 2021 (Moore et.al. 2023). Heterobasidion and other root diseases are not recorded in the ADS data but are present in the project area.

Recent hot droughts in California resulted in increased ponderosa pine mortality attributed to drought and WPB throughout the state. Western pine beetle is a bark beetle that infests the boles of >6" dbh ponderosa pine trees. This beetle can cause tree mortality in mature and second growth ponderosa and outbreaks usually occur in trees weakened by drought, fire, root disease, soil compaction or mechanical damage. Infestations increase dramatically following periods of drought. While stand density and water stress play a large role in ponderosa pine susceptibility to WPB (Fettig et al., 2007), the warm temperatures associated with recent droughts also likely contribute through direct effects to WPB population growth (Bentz et al., 2023). Ponderosa pine mortality is common throughout the project area especially on pine-dominated south-facing slopes and ridgetops. Vegetation management (thinning) is the most effective tool we have for reducing bark beetle-caused tree mortality (Fettig et al., 2007). Thinning improves tree vigor, reduces a tree's susceptibility to bark beetles and lowers the potential for catastrophic fire. The highest priority areas for thinning are in and around forested communities and at high value recreation sites.

Douglas-fir does not generally tolerate drought conditions well and hot-droughts, such as the most recent, are tolerated less. As a part of the pine and mixed conifer forest types, Douglas-fir mortality is primarily caused by FFB as a response to drought. Flatheaded fir borer is a Buprestid wood boring beetle that behaves like a bark beetle by feeding entirely underneath the bark instead of excavating galleries in the wood (Furniss and Carolin 1977; Schaupp and Strawn 2016). The life cycle of FFB normally lasts for one year but can be longer (2-4 years), depending on the quality of host as a food source (Furniss and Carolin 1977).

Flatheaded fir borer commonly kills healthy looking Douglas-fir growing at lower elevations on warm, dry sites around interior valleys or in locations where available moisture may be limiting (Goheen and Wilhite 2021, Buhl et al 2017). It is particularly aggressive during and after periods of drought. Patterns of mortality are often clumped on the landscape and concentrated along outer edges of stands, along ridges or drainages. Periods of extended drought also provide the environmental conditions for so called "secondary beetles" such as the Douglas-fir engraver beetle (*Scolytus unispinosus*) and Douglas-fir pole beetle (*Pseudohylesinus nebulosus*) to successfully attack and weaken mature Douglas-fir making them more susceptible to the FFB. Douglas-fir pole and engraver beetles typically attack small-diameter Douglas-fir trees and the tops of larger trees. Douglas-fir pole beetles and engraver beetles have one to two generations per year. Beetles usually emerge and attack in the spring.

If no management occurs these insects and diseases will continue to cause tree mortality and under current and projected climate models, hot droughts are expected to continue to stress the stands leading to greater amounts of tree mortality.

The most important pathogens of Douglas-fir in these mixed conifer forests include root disease fungi (*Armillaria* spp. and *Leptographium wageneri* var. *pseudotsugae*), butt- and heart-rot fungi (*Phaeolus schweinitzii* and *Porodaedalea pini*), and dwarf mistletoe (*Arceuthobium douglasii*). All are native to northwestern California and have co-evolved with their hosts for millions of years. These pathogens interact with insects to drive the background mortality rate of Douglas-fir. For most of these pathogens there is little or no known resistance since their hosts may persist and reproduce for many decades, and often centuries before being killed, often by insects such as the FFB.

Co-occurrence of pathogens and insects are common and account for most of the biotic-driven mortality in mixed conifer forests. Attack by weak pathogens and insects may be facilitated by the presence of more aggressive species but aggressive pathogens and/or insects may also co-occur on individual trees.

The site visit revealed a patch of pine and juniper mortality (mortality center) indicative of Heterobasidion root disease (HRD) (*Heterobasidion irregulare* can infect juniper) at Alpine View CG. The mortality center was associated with multiple pine stumps including one with laminated rot, a symptom associated with HRD. At Tannery Gulch CG, one downed Douglas-fir was found with rot symptoms indicative of HRD. Douglas-fir is susceptible to *H. occidentale*, but infections typically occur at a low enough incidence that it is not considered a problem from a management perspective in California. This species of Heterobasidion does not infect living pine or incense cedar.

Signs and symptoms of three other root diseases were found at Tannery Gulch CG; a previously known patch of Douglas-fir mortality caused by Armillaria root disease, a patch of ponderosa pine mortality caused by black stain root disease, and fruiting bodies of the velvet-top fungus that causes a root and butt rot of Douglas-fir.

As landscapes become increasingly droughty with climate change, the impacts of insects and diseases on Douglas-fir and other tree species will likely increase (Agne et al. 2018; Halofsky et al. 2022). Recent increases in Douglas-fir mortality raise concerns about the long-term resilience of this species, the loss of key ecosystem services, and the potential for increased fuel loading and uncharacteristic wildfire (Hessburg et al. 2019). At the same time, Douglas-fir mortality on some sites, such as former oak woodlands, presents opportunities for restoration.

In California, droughts are a regular occurrence, but the 2012–15 drought, which was characterized by large precipitation deficits and abnormally high temperatures and in some areas was the most severe in 1200 years (Griffin & Anchukaitis, 2014) taught us many lessons. This drought resulted in progressive canopy water stress and substantial mortality of dominant and co-dominant trees, much of which was attributed to WPB (Fettig et al. 2019). Higher stand densities can lead to greater water competition and drought stress (Fettig et al. 2019), and higher density of conspecific trees can lead to greater bark beetle infestation (Smith et al. 2005).

Recommendations:

- Thinning in the plantations and natural forests to reduce BA to 80-100 will reduce density and increase resilience to bark beetle attack.
- Sugar pine and other non-host species should be retained where found to increase species diversity further improving resilience of stands to tree mortality.

- Recommendations for treating stumps to reduce Heterobasidion infection centers is addressed in a previous report (FHP Report No. NC23-002).

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